U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-269 245

Palestine Reservoir, Anderson, Cherokee, Henderson, and Smith Counties, Texas

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

Apr 77

PB 268 245

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY
WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON
and
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

☆ U.S.G.P.O. 699-440

REPORT

ON

PALESTINE RESERVOIR

ANDERSON, CHEROKEE, HENDERSON, AND

SMITH COUNTIES

TEXAS

EPA REGION VI

WORKING PAPER NO. 69A

WITH THE COOPERATION OF THE

TEXAS WATER QUALITY BOARD

AND THE

TEXAS NATIONAL GUARD

APRIL, 1977

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1 REPORT NO.	2
3 RECIPIENT'S ACCESSION NO.	
4 TITLE AND SUBTITLE: Report on Palestine Reservoir, Anderson, Cherokee, Henderson, and Smith Counties, Texas	5 REPORT DATE: Prepared April 1977
	6 PERFORMING ORGANIZATION CODE
7 AUTHOR(S): Anonymous (National Eutrophication Survey Staff)	8 PERFORMING ORGANIZATION REPORT NO.: Working Paper # 654
9 PERFORMING ORGANIZATION NAME AND ADDRESS: National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330	10 PROGRAM ELEMENT NO.
	11 CONTRACT/GRANT NO.
12 SPONSORING AGENCY NAME AND ADDRESS: Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460	13 TYPE OF REPORT AND PERIOD COVERED: Final - 1974
	14 SPONSORING AGENCY CODE

15 SUPPLEMENTARY NOTES: Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16 ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17 KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

18 DISTRIBUTION STATEMENT: Release unlimited	19 SECURITY CLASS (This Report)	21 NO. OF PAGES: 49
	20 SECURITY CLASS (This page)	22 PRICE: A03 - A01

EPA Form 2220-1 (9-73)

CONTENTS

	Page
Foreword	ii
List of Texas Study Reservoirs	iv
Lake and Drainage Area Map	vi

Sections

I.	Conclusions	1
II.	Lake and Drainage Basin Characteristics	4
III.	Lake Water Quality Summary	5
IV.	Nutrient Loadings	11
V.	Literature Reviewed	16
VI.	Appendices	17

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYSIS APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Texas Water Quality Board for professional involvement, to the Texas National Guard for conducting the tributary sampling phase of the Survey, and to those Texas wastewater treatment plant operators who voluntarily provided effluent samples.

Hugh C. Yantis, Jr., Executive Director of the Texas Water Quality Board, and John B. Latchford, Jr., Director, and the staff of the Field Operations Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Thomas Bishop, the Adjutant General of Texas, and Project Officer Colonel William L. Seals, who directed the volunteer efforts of the Texas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

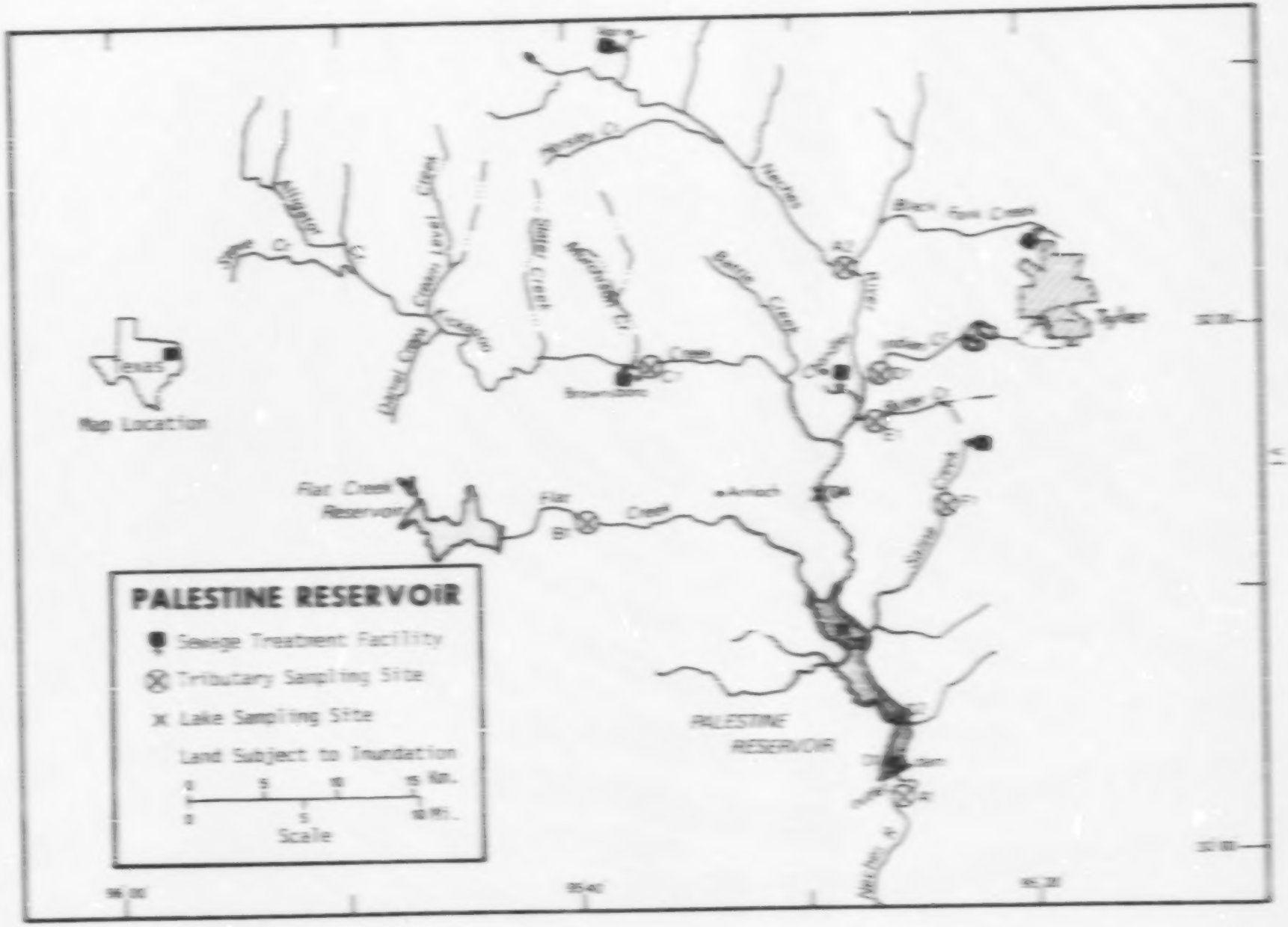
NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Texas

NAME	COUNTY
Amistad	Val Verde
Bastrop	Bastrop
Belton	Bell, Coryell
Braunig	Bexar
Brownwood	Brown
Buchanan	Burnet, Llano
Caddo	Harrison, Marion, TX; Caddo Parish, LA
Calaveras	Bexar
Canyon	Comal
Colorado City	Mitchell
Corpus Christi	Jim Wells, Live Oak, San Patricio
Diversion	Archer, Baylor
Eagle Mountain	Tarrant, Wise
Fort Phantom Hill	Jones
Houston	Harris
Kemp	Baylor
Lake O'The Pines	Camp, Marion, Morris, Upshur
Lavon	Collin
Lewisville (Garza-Little Elm)	Denton
Livingston	Polk, San Jacinto, Trinity, Walker

Lyndon B. Johnson	Burnet, Llano
Medina	Bandera, Medina
Meredith	Hutchinson, Moore, Potter
O. C. Fisher (San Angelo)	Tom Green
Palestine	Anderson, Cherokee, Henderson, Smith
Possum Kingdom	Palo Pinto, Stephens, Young
Sam Rayburn	Angelina, Jasper Nacogdoches, Sabine, San Augustine
Somerville	Burleson, Lee, Washington
E. V. Spence	Coke
Stamford	Haskell
Stillhouse Hollow	Bell
Tawakoni	Hunt, Rains, Van Zandt
Texoma	Cooke, Grayson TX; Bryan, Johnston, Love, Marshall, OK
Travis	Burnet, Travis
Trinidad	Henderson
Twin Buttes	Tom Green
White River	Crosby
Whitney	Bosque, Hill
Wright Patman (Texarkana)	Bowie, Cass


Texas
Map Location
PALESTINE RESERVOIR
Sewage Treatment Facility
Tributary Sampling Site
Lake Sampling Site
Land Subject to Inundation
0 5 10 15 Km.
0 5 10 Mi.
Scale
Flat Creek Reservoir
PALESTINE RESERVOIR
Flat Creek
Mud Creek
Hurricane Creek
Bonita Creek
Alligator Creek
Bowles Creek
Black Fork Creek
Tyler
Athens
Brownsboro

PALESTINE RESERVOIR

STORET NO. 4824

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Palestine Reservoir is eutrophic; i.e., well supplied with nutrients and quite productive. Whether nutrient enrichment is beneficial or deleterious depends on the actual or potential effect on the uses of the reservoir. In this regard, no nuisance conditions are known to personnel of the Texas Water Quality Board and there is little or no impairment of the designated beneficial uses of this water body.

Palestine Reservoir ranked twenty-first in overall trophic quality when the 39 Texas reservoirs sampled in 1974 were compared using a combination of six parameters*. Seventeen of the reservoirs had less and one had the same median total phosphorus, 18 had less and one had the same median dissolved phosphorus, 26 had less and one had the same median inorganic nitrogen, 18 had less mean chlorophyll a, and 14 had greater mean Secchi disc transparency. Marked depression of hypolimnetic dissolved oxygen occurred at stations 1 and 2 in August.

* See Appendix A.

Survey limnologists noted surface algal mats at station 4 in May. Previous investigators have noted that the upper portions of this water body are covered with dense growths of aquatic vegetation (Smith, 1974).

B. Rate-Limiting Nutrient:

The algal assay results indicate that Palestine Reservoir was limited by phosphorus at the time the sample was taken (03/19/74). The reservoir data indicate phosphorus limitation at three of the four stations in March, at two stations in May, and at two stations in November.

C. Nutrient Controllability:

1. Point sources--During the sampling year, point sources contributed 65.7% of the total phosphorus input to Palestine Reservoir. The Tyler North Plant contributed an estimated 58.6% of this total.

The present phosphorus loading of 0.67 g/m^2/year is nearly 1.8 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 15). Because most of the reservoir is phosphorus limited, all point-source loads should be minimized to the greatest practicable extent. A 75% phosphorus reduction at the Tyler North Plant would reduce the present loading to 0.38 g/m^2/year and, if Vollenweider's eutrophic level is applicable to Texas reservoirs, should result in an improved

trophic condition in the reservoir once a new phosphorus equilibrium has been established.

2. Non-point sources--Non-point sources contributed an estimated 34.1 of the total phosphorus load during the sampling year. After point sources were subtracted, the Neches River contributed 6.1 and Kickapoo Creek contributed 9.7 . Other gaged tributaries included Flat and Indian creeks which contributed 2.9 and 0.9 of the total, respectively. Ungaged tributaries and immediate drainage contributed an estimated 12.1 of the total.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS[†]

A. Morphometry[††]:

1. Surface area: 103.44 kilometers².

2. Mean depth: 4.9 meters.

3. Maximum depth: 15.2 meters.

4. Volume: 508.001 x 10^6 m^3.

5. Mean hydraulic retention time: 1.3 years (based on outflow).

B. Tributary and Outlet
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Neches River	564.6	2.082
Flat Creek	170.9	1.150
Kickapoo Creek	600.9	3.730
Indian Creek	60.1	0.404
Minor tributaries & immediate drainage -	701.6	5.250
Totals	2,098.1	12.616

2. Outlet -

Neches River	2,201.5**	12.080

C. Precipitation***:

1. Year of sampling: 120.0 centimeters.

2. Mean annual: 117.4 centimeters.

† Table of metric conversions--Appendix B.
†† Latchford, 1974.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1971-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Palestine Reservoir was sampled four times in 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two or more depths at four stations on the reservoir (see map, page vii). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the March visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 12.8 meters at station 1, 11.6 meters at station 2, 7.6 meters at station 3, and 3.4 meters at station 4.

The sampling results are presented in full in Appendix D and are summarized in the following table (the August nutrient samples were not properly preserved and were not analyzed).

[illegible]

[illegible]

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/09/74	1. Melosira sp.	1,452
	2. Chroomonas sp.	881
	3. Cryptomonas sp.	674
	4. Microcystis sp.	441
	5. Ankistrodesmus sp.	285
	Other genera	907
	Total	4,640
05/17/74	1. Melosira sp.	1,012
	2. Chroomonas sp.	534
	3. Dactylococcopsis sp.	138
	4. Microcystis sp.	138
	5. Crucigenia sp.	120
	Other genera	668
	Total	2,650
08/13/74	1. Dactylococcopsis sp.	1,297
	2. Melosira sp.	605
	3. Cryptomonas sp.	577
	4. Pennate diatoms	548
	5. Raphidiopsis sp.	490
	Other genera	1,585
	Total	5,102
11/01/74	1. Melosira sp.	947
	2. Dactylococcopsis sp.	245
	3. Coccoid cells	106
	4. Nitzschia sp.	105
	5. Microcystis sp.	35
	Other genera	210
	Total	1,647

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
03/09/74	1	3.1
	2	3.4
	3	4.5
	4	4.1
05/17/74	1	1.7
	2	4.5
	3	4.7
	4	19.3
08/13/74	1	2.6
	2	14.5
	3	11.9
	4	10.5
11/01/74	1	3.3
	2	5.1
	3	4.7
	4	11.8

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.005	0.183	1.9
0.050 P	0.055	0.183	5.6
0.050 P + 1.0 N	0.055	1.183	20.6
1.0 N	0.005	1.183	2.3

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity

of Palestine Reservoir was moderately high at the time the sample was collected (03/19/74). Also, a significant increase in yield with the addition of phosphorus alone indicates that the reservoir was limited by phosphorus at that time. Note that the addition of nitrogen alone resulted in a yield which was not significantly greater than that of the control.

The reservoir data indicate phosphorus limitation in March (the mean inorganic nitrogen/orthophosphorus ratio was 17/1); narrow nitrogen limitation in May (the mean inorganic nitrogen/orthophosphorus ratio was 13/1); and phosphorus limitation in November (the mean inorganic nitrogen/orthophosphorus ratio was 14/1).

The reservoir data indicate a spatial and temporal combination of limiting nutrients. Following is a tabulation of the mean inorganic nitrogen/orthophosphorus ratios for each of the sampling station and times with the indicated limiting nutrient in parentheses. Note that those stations nearest nutrient point sources (e.g., station 4) tended toward nitrogen limitation.

Station	03/09/74	05/17/74	11/01/74
1	22/1 (P)	13/1 (N?)	24/1 (P)
2	17/1 (P)	17/1 (P)	18/1 (P)
3	15/1 (P)	16/1 (P)	12/1 (N)
4	5/1 (N)	6/1 (N)	5/1 (N)

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Texas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the months of April and May when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Texas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads at station 8-1, in kg/km^2/year, and multiplying by the ZZ area in km^2.

The operators of the Brownsboro, Tyler, Henderson County Municipal Water Supply, and Van wastewater treatment plants did not participate in the Survey; nutrient loads from these sources were estimated at 1.134 kg P and 3.401 kg N/capita/year, and flows for the Brownsboro and Tyler North Plant were estimated at 0.3785 m^3/capita/day.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal[1]

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Brownsboro	510	stab. pond	193.0	Kickapoo Creek
Tyler North plant	36,000	tr. filter	13,626.0	Black Fork Creek*
Kelly Springfield Plant*	1,400	contact stab.	113.6*	Saline Creek
Henderson Cty. Mun. Water Supply*	500	contact stab.	283.9*	Unnamed Creek/ Palestine Res.
Van*	2,000	contact stab.	1,135.5*	Big Sandy Creek/ Neches R.

[1] Anonymous, 1971.
* Wyatt, 1976.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Neches River	4,235	6.1
Flat Creek	2,005	2.9
Kickapoo Creek	6,735	9.7
Indian Creek	620	0.9
b. Minor tributaries & immediate drainage (non-point load) -	8,420	12.1
c. Known municipal STP's -		
Brownsboro	580	0.8
Tyler		
North plant	40,825	58.6
Kelly Springfield plant	1,590	2.3
Henderson Cty. Mun. Water Supply	565	0.8
Van	2,270	3.2
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	1,810	2.6
Total	69,655	100.0

2. Outputs -

Lake outlet - Neches River 8,995

3. Net annual P accumulation - 60,660 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Neches River	49,590	9.2
Flat Creek	27,335	5.0
Kickapoo Creek	96,430	17.8
Indian Creek	6,845	1.3
b. Minor tributaries & immediate drainage (non-point load) -	112,255	20.7
c. Known municipal STP's -		
Brownsboro	1,735	0.3
Tyler		
North plant	122,435	22.6
Kelly Springfield plant	4,760	0.9
Henderson Cty. Mun. Water Supply	1,700	0.3
Van	6,800	1.3
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	111,675	20.6
Total	541,560	100.0

2. Outputs -

Lake outlet - Neches River	231,505

3. Net annual N accumulation - 310,055 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Neches River	8	88
Flat Creek	12	160
Kickapoo Creek	11	160
Indian Creek	10	114

* See Working Paper No. 175.

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Butler Creek	0.036	0.678
Saline Creek	0.060	0.966

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.67	0.59	5.24	1.00

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Palestine Reservoir:

"Dangerous" (eutrophic loading)	0.38
"Permissible" (oligotrophic loading)	0.19

V. LITERATURE REVIEWED

Anonymous, 1971. Inventory of municipal waste facilities. EPA Pub. No. OWP-1, vol. 6, Wash., DC.

Latchford, John B. Jr., 1974. Personal communication (morphometry). TX Water Qual. Bd., Austin.

Smith, Stephen F., 1974. Fishery management recommendations. Fed. Aid Proj. F-25-R-1, TX Parks & Wildlife Dept., Austin.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Wyatt, Linda B., 1976. Personal communication (discharge points of Tyler STPs). TX Water Qual. Bd., Austin.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] RANKED -- [illegible] NAL

ROW	LAKE CODE	LAKE NAME	[illegible]
1	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]

LAKES RANKED BY INDEX NO.

RANK	LAKE CODE	LAKE NAME	INDEX NO.
29	421	LYNDA & LOMBARDY LAKE	229
30	424	TEXAS LAKE	217
31	425	SHERVILLE LAKE	206
32	426	SAN ANGELO RESERVOIR	200
33	423	CHAMPION LAKE	176
34	405	SPUR LITTLE ELM RESERVOIR	173
35	434	TRINIDAD	164
36	404	BRYANS LAKE	159
37	411	CORPUS CHRISTI LAKE	155
38	427	HOUSTON LAKE	139
39	428	LIVINGSTON LAKE	91

[illegible] OF LAKES WITH HIGHER VALUES [illegible] OF LAKES WITH HIGHER VALUES

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	[illegible] CHLA	[illegible] SECCHI	[illegible] COLOR	[illegible]
[illegible]	[illegible]	29 (11)	55 (21)	24 (9)	3 (1)	67 (25)	64 (24)
[illegible]	[illegible]	19 (7)	47 (18)	5 (2)	11 (7)	62 (23)	34 (13)
[illegible]	[illegible]	89 (33)	37 (14)	87 (32)	47 (18)	17 (6)	51 (19)
[illegible]	[illegible]	32 (12)	78 (29)	37 (14)	21 (8)	62 (24)	36 (14)
[illegible]	[illegible]	11 (4)	51 (19)	13 (5)	14 (6)	72 (27)	13 (5)
[illegible]	[illegible]	79 (24)	34 (13)	61 (23)	43 (17)	17 (8)	21 (7)
[illegible]	[illegible]	88 (33)	21 (7)	92 (35)	82 (33)	17 (8)	84 (32)
[illegible]	[illegible]	0 (0)	61 (22)	11 (4)	5 (2)	42 (25)	6 (6)
[illegible]	[illegible]	59 (22)	21 (7)	58 (22)	61 (23)	44 (17)	63 (23)
[illegible]	[illegible]	84 (32)	61 (22)	78 (29)	69 (34)	17 (8)	63 (23)
[illegible]	[illegible]	62 (24)	51 (19)	75 (33)	71 (27)	17 (8)	74 (28)

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

APPENDIX D

PHYSICAL and CHEMICAL DATA

APPENDIX E

TRIBUTARY DATA

[illegible]

[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							

* [illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L *	MG/L *
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

* VALUE KNOWN TO BE
LESS THAN INDICATED